12 AUGUST 1980 (FOUO 10/80) 1 OF 1

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12 August 1980

West Europe Report

SCIENCE AND TECHNOLOGY

(FOUO 10/80)

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JPRS L/9248

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WEST EUROPE REPORT

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CONTENTS

INDUSTRIAL TECHNOLOGY

MACHINE TOOL INDUSTRY ON DISPLAY

Paris AIR & COSMOS in French 7 Jun 80 pp 29-31

[Article by G. C.: "Eleventh Machine Tool Biennial"]

[Text] Following is a report on the machine tool biennial which took place in Paris between 29 May and 6 June. This exposition was predictably under the sign of the omnipresence of digital input informatics (today few of the machines exhibited at the biennial are without digital inputs!), and by computer-assisted design-manufacturing systems.

Within the framework of the biennial the third days of automated production, sponsored by ADEPA took place at Port de Versailles.

These days were inaugurated by ADEPA President Michel Barba who opened the round of conferences with the following warning: "It is later than you think," thus emphasizing at the onset the need to accelerate the development of production automation in the face of the stated ambitions of the competition, Japanese in particular. These words were echoed in the speech by Lefrancois, deputy director of DIELI, who, while giving assurances to industry that the government would help, also insisted on making the French industrialists aware of their responsibility in this important industrial stake.

Some 30 papers were read to some 350 people. They emphasized techniques and prospects such as:

- machining techniques;
- machine design;
- digital input and CAD/CAM;
- robotics;
- personnel, etc.

The automobile and aerospace industries were quite frequently mentioned in the course of the presentations, as could be easily understood. Let us note, in particular, the position of Dassault, acknowledged as one of the world leaders in computer-assisted design and manufacturing, a topic we discussed in our issue No 815, p 34.

According to a study made by UFB-Locabail, the rate of use of digital inputs in small and medium enterprises is under 13 percent, while over two-thirds of them remain opposed to digital inputs. The main reasons cited against digital inputs are the high cost of the initial investment and the inadaptability of digital inputs to their output. The enterprises which have adopted digital inputs have most frequently selected a French supplier.

Dubus

An automatic centering machine was exhibited by Dubus, Model DHCFA 30 or HCFM 70, equipped with two centering heads.

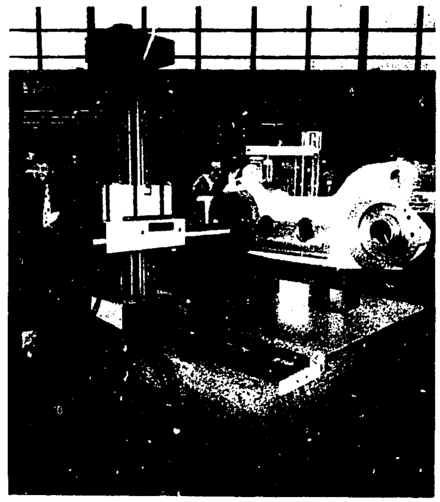
Feeding power per machining unit is 2.2 kW; holding capacity, 6 mm minimum and 30 mm maximum.

Ernault-Somua

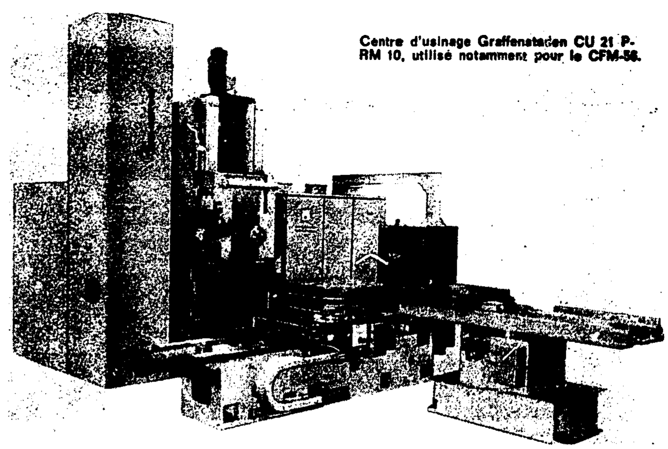
Ernault-Somua exhibited its range of digital input lathes. These are general purpose lathes classified as models 350-450 and 600, the numbers representing, in fact, roughly the clearance above the bench. The power of the broach motor may go as high as 36 kW, with a speed of 2,400 rpm. The turning speed of the part may vary according to the diameter of the machined part. The slides are for models of the upper range of the gamut, made of forged steel with roller flanges.

Equally shown by Ernault-Somua was the MC 132 machining center which is, in fact, part of a range of machining centers identified as MC 132/232 or 332. These are vertical broaches consisting of a family of digital input milling machines.

Model 132 has an ISO 40 broach powered by a 9 kW dc motor developing 3,000 rpm. Optionally, the power of the broach could be raised to 18 kW and the speed to 6,000 rpm. Models 232 and 332 are equipped with an ISO 45 broach with a 19 kW 3,000 rpm motor. The strokes are about 500 cubic for the MC 132, 600 cubic for the 232 and 1,200 x 500 x 600 for the 332. Also shown by Ernault-Somua are the three-axle digital input Z3 PNC and Z3 PNV milling machines. Let us note among a very big selection (let us recall that Ernault-Somua is one of the leading machine tool companies in France whose 1980 turnover was 500 million francs), the high power W100N lathe whose main characteristics are as follows: bench diameter 760 mm; power up to 53 kW; distance between centers, up to 3,300 mm; broach speed up to 2,200 rpm.



Three dimensional Sagem control machine shown in AIR ET COSMOS No 815, p 49.



The Graffenstaden CU 21 P--RM 10 machining center, used specifically for the CFM-56.

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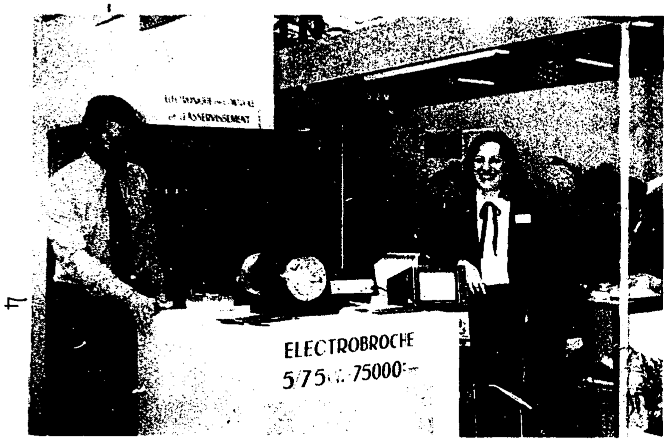
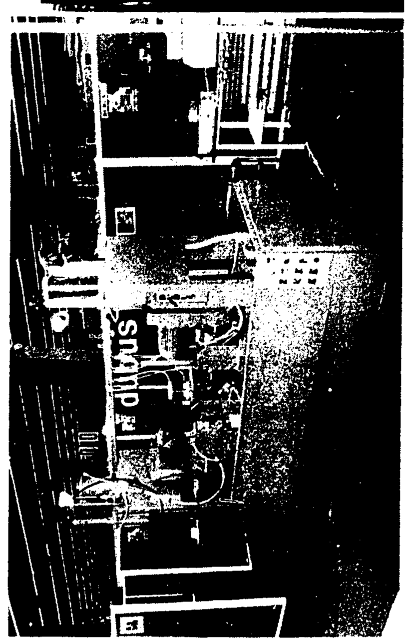


One of the stars of the biennial, the S2M high speed magnetic bearings drill.

Photograph of the Rito exhibit. Rito enjoys a worldwide reputation for its tungsten carbide tools extensively used in the aeronautic industry.

Gaston Dufour exhibit.



Dubus centering machine.

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The lathe can accomodate two tables with, for instance, seven reaming rods and six outside tools (Ernault-Somua patent).

In recent years Ernault-Somua has signed several contracts in the aerospace industry, namely with Snecma, Aerospatiale, Boeing, Garrett, Pratt and Whitney Montreal, and others.

Gendron

Noteworthy in the big exhibit of the LINE-PSM Group was the Gendron T85 CNC digital input cylindrical rectifying machine. This machine offers the possibility to control the automatic feeding of parts directly through central programming and makes the use of a flexible program possible. According to the manufacturer, the following characteristics make this machine highly productive:

- a single assembling and disassembling of the part for total machining;
- instant machine tuning;
- fast moving speed of 10 meters per minute;
- integrated automatic feeding, i.e., the manipulator movements are controlled directly through the parts program of the digital input;
- flexible program.

Gerber

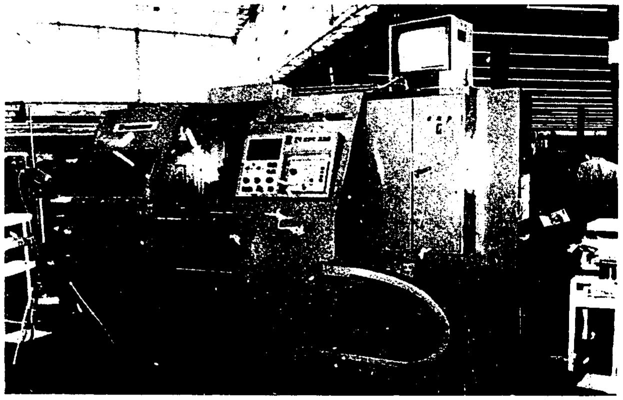
Gerber exhibited its latest model of an interacting graphic system, the IDS-80. This is a CAD information system through which the design of a part is progressively displayed on a screen in two or three dimensions, starting with an outline. The designer can then make the model pivot and show it under several angles, and undertake modifications, surface intersections, etc. The design engineer could then retrieve the developed part and control the digital input information needed for the manufacturing of the part (CAM).

Graffenstaden

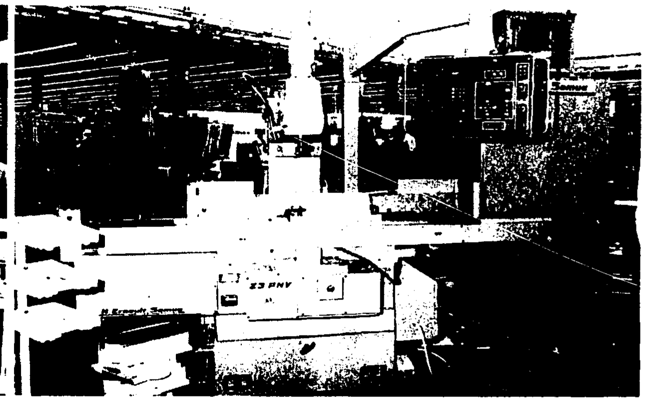
Graffenstaden exhibited two novelties:

- The lathe G 3S-CN with digital input NUM 460 TM, 2 x 2 axis. This is a multi-axis lathe with two crossing carriages rolling on precision roller screws and powered by direct current. The carriages are equipped with tool carrying capstans with eight different positions, or tool carrying blocks. Distance between centers: 600 mm; pass ahead of carriage, 215 mm; before saddle, 390 mm. Power of broach motor, from 12 to 18.5 kW;

- Horizontal broach machining center, Model CU21PRM25. The model comes equipped with a NUM 460 4 axle digital input. The broach carriage has two speeds powered by direct current. The slides are made of rectified forged steel with Turcite counterslides. The turning plate has 360,000 positions. The changer has been designed for 32, 45, or 60 ISO 50 tools. Runs: 1,500, 2,000 or 2,600 in X, 910 or 1,260 in Y, and 900 in Z. Power: 20 kW.

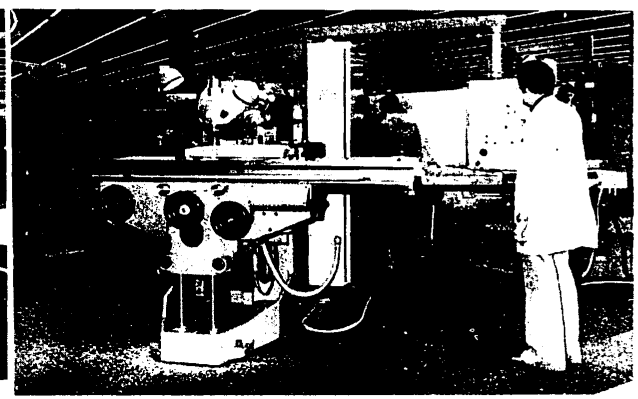


The Ernault-Somua Transmum machine.



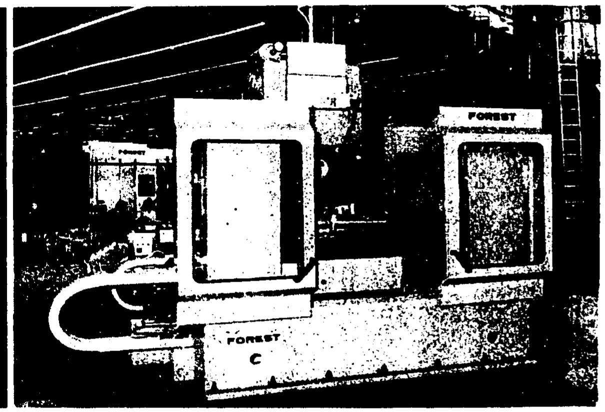
Ernault-Somua Z3PNV milling machine.

Gendron T85 rectifier.



Hure P 2000 milling machine.

Sculfort CN25 lathe.



TMI Forest TC7 machining center.

Marwin tungsten carbide tool. Finger points at Stellite-added part.

Hure

Hure exhibited, among others, a fixed bench milling machine with paraxial positioning and machining, known as Model P 2000. Main characteristics: runs: 1,650 x 980 x 1,000; milling head ISO 40; installed power: 25 kW; broach power 8.8 kW; speeds ranging from 30 to 2,066 rpm. Fast advance of 3,000 mm/mn; Heidenhain TNC 131 digital input.

Marwin

As we know, several years ago Marwin stopped the production of machine tools. However, the company is still active, among others, in the production of tungsten carbide tools. Currently, Marwin is developing its market in France where it will be selling a range of aeronautics tools through distributors. The SEICMO company is one of its main distributors which also provides maintenance service. The new Marwin-Aeronautique milling machines have been especially designed for "pocketing" milling and, particularly, for milling warping panels. The patented design consists of a combination of 30° helicoidal carbon plates with a Stellite central dip which avoids the deterioration of the carbide in the slow speed area around the center. The frontal design makes both sweeping and vertical use possible while eliminating the risk of localized heating at the end of the dip. This design also allows milling in all positions.

Sculfort

Sculfort exhibited the CN 25 digital input lathe with tool changer and storage, for machining a lorry pinion with a 240 mm external diameter.

The lathe includes an automatic triple jaw chuck developing a power of 27 kW. The tool changer has a capacity for eight broaching benches. The operation, as demonstrated, included seven stages with cutting speeds ranging from 120 to 500 m/mn, and speeds ranging from 0.25 to 0.4 mm/t.

Industrial Robotics

The National Institute of Applied Sciences (INSA) of Villeurbanne will organize an exposition of industrial robotics on 12 and 13 June next. The event is sponsored by DIMME, with the assistance of ADEPA. The program will include reports on the identification of the shapes and robot technology, and the study of assignments and ergonomy, and the designing and utilization of robots. The concluding topic will deal with the future and the prospects of industrial robotics. Information may be obtained by calling (7) 893-71-12, boxes 3508 or 3587.

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TRANSPORTATION

DEVELOPMENT OF RESEARCH PASSENGER CAR BEGINS

Government Program

Stuttgart ATZ in German Feb 80 pp 59-62

/Article by Dr Eng Jürgen Bandel, Federal Ministry for Research and Technology, Heinemann Street 2, 5300 Bonn 2/

/Text/ Within the scope of the program "Motor Vehicles and Road Traffic," the Federal Ministry for Research and Technology (BMFT) is funding the development of a research passenger car that is designed for the requirements of the current decade. Five automobile companies and a collegiate working association (Darmstadt, Aachen, Berlin, and Stuttgart) participated in the first phase of this project. This phase was concluded with an evaluation of the ideas and of the resulting specifications manuals.

Phase 2 began in the fall of 1979. Competing vehicle designs were implemented; three corporations (Audi NSU Auto Union, Daimler-Benz, and Volkswagenwerk) as well as the collegiate working association participated.

The present introductory article by Dr. Bandel deals with the project "Research Passenger Car." Dr. Bandel is responsible for the funding area of motor vehicles and road traffic in the BMFT. In this publication and in the following issues, the participating companies and scientific institutes will voice their proposals for the future development of the passenger car.

The Editors

Abstract

Within the scope of the program "Motor Vehicles and Road Traffic," the Federal Ministry for Research and Technology promotes the development

of a research passenger car according to the requirements of the coming decade. Within three phases of research and development, the establishment of specifications, the construction of prototype vehicles, and the testing of the development result, technological proposals are prepared for solutions by an integrated general concept with respect to the setting of aims as to improved exhaust and noise emissions. Economy and utility are futher criteria of the development project being intended to concepts suitable for series production.

Phase 1 was concluded by the evaluation of the specifications which were promoted in a competitive way. With regard to realization in Phase 2, the competing designs of the firms Audi NSU, Daimler-Benz, Volkswagen and of the cooperation group of the universities Darmstadt, Aachen, Berlin and Stuttgart were taken into account.

The state of the art of the designs of all participants will be reported on subsequently.

Structure and Significance of Traffic

The Federal Republic of Germany is among those countries that have an especially well-developed traffic system. Dense networks exist for road, rail, water, and air traffic. In 1978, the total traffic output was 582 billion person-kilometers, and freight traffic amounted to 1132 billion ton-kilometers. From a statistical point of view, in the year 1978, every citizen of our country traversed more than 8000 km with a motor vehicle or a public means of transportation. The goods transport per capita attained a value of more than 16,000 ton-kilometers.

In the medium term, a further growth of mobility and demand for freight transport is to be expected. According to existing forecasts, the development will proceed differently. Inasmuch as no decisive changes in the traffic offering can be effected, the largest growth rates will continue to apply to road traffic and air traffic, although saturation trends are here inescapable.

Starting from the present situation, several essential factors must be taken into account in view of future development. About 20 percent of the gross social product in our country is used for transportation and traffic purposes, without taking into account the time cost fraction. In expenditures of private households, traffic claims nearly the same percentage fraction. The most expensive investments are found in the public budgets for traffic.

About every fifth worker is employed in traffic and in traffic-related industry. The entire population participates actively in the traffic business.

As regards the subdivision of traffic means, the dominance of road traffic is inescapable: More than 80 percent of passenger traffic takes place with the automobile as an individual traffic means. Nearly 50 percent of freight traffic is implemented by trucks.

Transportation and traffic have special significance in terms of macro- and micro-economics. The state is the overwhelmingly decisive factor as regards overall responsibility. It therefore bears an increased obligation for designing today's and tomorrow's traffic developments.

Development of Motor Vehicle Traffic in the Federal Republic of Germany

Since 1945, the economic and social structure of the Federal Republic of Germany has scarcely been stamped more by any technical achievement of the 20th century than by the motor vehicle and by its associated development of road traffic.

Numerous factors have substantially raised the demand for transportation of passengers and goods. Among these are: the increased living standard, changes in leisure time behavior, a more dispersed residential structure, the widespread separation of residence and job, increasing industrialization, and expansion of trade relationships. In 25 years, the number of motor vehicles has increased more than tenfold. It rose from about 2 million in 1950 to 25 million in 1978. In 1950, the proportion of passenger cars in the total stock was barely 30 percent. In 1975, this figure was about 86 percent. The annual travel output in passenger and station wagon traffic in 1977 was 266 billion kilometers. Thirty-three billion kilometers were traversed by trucks, Figure 1.

The maintenance of our social and economic structure requires a high degree of mobility. The striving for a higher quality of life presupposes a reliable and flexible supply in all areas. With the development of transportation in road traffic, and with the position of the motor vehicle associated therewith, the automobile industry has developed to one of the most significant economic factors in the FRG. In recent years, it has more and more clearly grown to occupy the role of a key industry.

The strong increase of motor vehicles not only exerted a positive influence on mobility and on economic life, but also created severe problems (accidents, environmental damage). It must be expected that, within the scope of a sensible division of tasks in integrated overall traffic, a high proportion of traffic and transportation will continue to belong to motor vehicles, even if the offering of public traffic means expands in the future. For area coverage and for mobility in less densely settled areas, individual motcr vehicles are also the best solution in the long term.

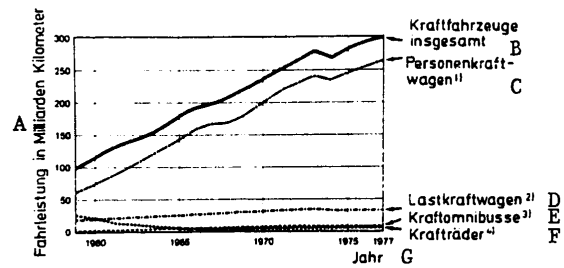

Bild 1. Gesamtfahrleistungen deutscher Kraftfahrzeuge – Quelle: „Verkehr in Zahlen" BMV
1) einschließlich Kombinationsfahrzeuge
2) einschließlich Sonderkraftfahrzeuge und Zugmaschinen
3) einschließlich O-Busse
4) einschließlich Mopeds

Figure 1: Total Driving Output of German Motor Vehicles - Source: "Traffic in Figures" BMV (Berlin Metal Working Plant)
1) including station wagons
2) including special motor vehicles and tractors
3) including O-buses
4) including Mopeds

Key:
A. Driving output in billion kilometers
B. Motor vehicles, total
C. Passenger cars1)
D. Trucks2)
E. Buses3)
F. Motorcycles4)
G. Year

Motor vehicle traffic entails certain problems:

a large safety risk
considerable environmental pollution
a high energy demand
complete dependence on petroleum
the need for large traffic surfaces.

These problems must be reduced by the further technical development of the overall system which comprises motor vehicles and road traffic. Government funding of research and technological developments is necessary as a supplement to the marketing objectives of industry. Prospective solutions will thus be developed in the interest of the community and will then be made available. In the medium to long terms, the expected aggravation of problems concerning energy supply and environmental protection will require new technologies.

Tasks of Government Research Funding

The future development of motor vehicles and of road traffic must increasingly be oriented in accord with often contradictory particular requirements, namely:

securing mobility and supply,
improving safety for health, life, and property,
maintaining and improving the living space, securing environmental compatibility,
improved energy utilization, more conservative and flexible use of raw materials,
increasing scientific-technical as well as economic capability.

The state cannot achieve these aims by purely administrative and legal measures. By intensifying technological research and development, these problems, which we confront today and which will become more formidable in the future, must be recognized and attacked in good time. The evaluation criteria must here be guided by long term economic developments and forecasts and by the capabilities of our society.

The Project of Central Interest: "The Research Passenger Car"

Within the scope of promoting research and development in the area of "motor vehicles and road traffic" by the Federal Ministry of Research and Technology, significant theoretical and technological contributions could be made, since 1972, to the solution of pollutant and noise emission, energy and raw materials consumption, and problems relating to traffic safety.

The results of 5 years of promotion can be summarized in a kind of interim balance sheet. In combination with new objectives, they form a central point of interest for future work. Besides the basic research problems, the research and development project "Demonstration of Technical Automotive Research Results in Integrated Global Designs of Passenger Car Experimental Models" has been publicized, since the beginning of 1978, as a system-integrating line.

This project was initiated and funded by the Federal Ministry for Research and Technology. As a contribution towards securing a long term technological advance, this project integrated, demonstrated, and tested novel motor vehicle technologies on several experimental vehicles.

Within the framework of the requirements that are of particularly urgent public interest, these novel technologies indicate a basic potential for advanced technological solutions. The particular requirements involve:

conservation of energy and resources
environmental compatibility
safety
economy and usefulness

The individual solutions are always elucidated by way of a scenario.

The objective of this demonstration project is to develop and present passenger cars, which will take into account new research results, and which will represent qualitative and quantitative improvements over comparable mass-produced vehicles, as regards the above-mentioned requirements. The starting point here is that various solution strategies are possible to fulfill these requirements. When evaluating the designs, more extensive improvements in one area can sometimes be here accounted against lesser improvements in another area. In this way, the center of interest can shift somewhat and priorities can be assigned somewhat differently. The project offers the possibility of presenting individual results of current research projects within the framework of overall vehicle designs. It also demonstrates the success of previous promotion by the Federal Ministry for Research and Technology, and it points to foreseeable guidelines for further research and development. The project is being executed in individual component steps, Figure 2.

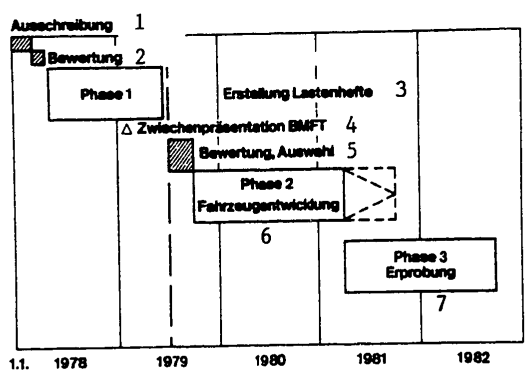

Figure 2: Program Sequence of the Central Project "Research Passenger Car"

Key:

1. Publication
2. Evaluation
3. Generation of specification manuals
4. Intermediate presentation BMFT
5. Evaluation, selection
6. Phase 2 vehicle development
7. Phase 3 tryout

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The first phase, setting up a specifications manual, was begun in May 1978. This was completed in June 1979. The specifications manuals formed the basis for deciding on the experimental models to be built in Phase 2. Closely connected with the construction of prototypes is their testing for demonstrating the achievement of development objectives. This will occur in Phase 3.

General Guidelines

In the publication of the funding project, the general specifications and special individual requirements on the average constituted a 30 percent improvement with respect to mass-production standards.

In particular the following specifications were used as a basis:

a vehicle with four seats,
more than 400 kg extra load,
preservation of the present degree of comfort in the respective vehicle class (e.g. dimensions, interior noise),
preservation of current driving performance and range (e.g. acceleration from 0 to 100 km/h in at least 13 s, maximum speed at least 140 km/h, range greater than 400 km),
at least adherence to directives and guidelines that are presently applicable or that are expected in the Federal Republic of Germany, as well as consideration of trends and requirements, in the USA, specific guide values were listed as supplements.

Saving of Energy and Raw Materials

The requirements for saving energy and raw materials are gaining in significance. An analysis of total energy consumption, based on the lifetime of a vehicle, shows that the major fraction of nearly 82 percent involves fuel consumption, Table 1.

A prereduction of fuel consumption is therefore to be regarded as an essential objective. According to the ECE A70, the prescribed fuel consumption values assign a 50 percent weight to city traffic and respectively 25 percent each to constant speeds at 90 and 120 km/h. These values are plotted in Figure 3. The consumption data for various passenger cars of the 1976/77 model year are also plotted. A regression line A shows the average consumption data. Consumption reduced by 30 percent corresponds to line B. In order to adapt to the available test equipment, the consumption data will refer to the test categories prescribed in the exhaust gas legislation (C). This does indeed result in disadvantages for heavy vehicles of a weight category. However, in

Table 1: Energy Consumption of a Passenger Car at 100,000 km Driving Distance, Weight 1,000 kg

Production of this	12,000 kWh	≙ 9.16%
Components	9,000 kWh	
Assembly	3,000 kWh	
Operation of this	109,000 kWh	≙ 83.21
Fuel consumption	107,000 kWh	≙ 81.68
One body repair	2,000 kWh	
Recycling	10,000 kWh	≙ 7.63
Total	≧ 131,000 kWh	≙ 100%

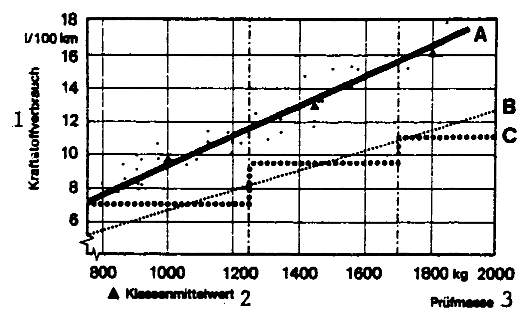

Figure 3: Fuel Consumption of Passenger Cars Approved in the Federal Republic of Germany, in Dependence on the Test Weight Determined According to DIN 70030, in the Version of July 1978: City Traffic (EFZ) = 50 Percent, 90 and 120 km/h each = 25 Percent

Key:
1. Fuel consumption
2. Average value for the category
3. Test weight

view of the lower fuel consumption for lighter vehicle weights, this fact supports the trend toward light construction.

In general, the geological availability of materials required in automobile construction is regarded as noncritical until the year 2000. Substitution purely for improving the range of raw material deposits therefore appears necessary only with a few materials, e.g. zinc, copper. Substitution of present materials by light materials, however, can favorably affect fuel consumption. An increased lifetime is desirable from the point of view of protecting raw material reserves. The difficulties are associated with determining a favorable lifetime under all boundary conditions. However, the difficulties as well as the possibilities of production engineering and the expenditures for vehicle maintenance can be estimated only with difficulty for a lifetime up to 20 years.

Motor vehicles are among the industrial products with the highest recycling rates. Further increases of this rate are possible by the trend of rising prices for raw materials and by carefully considered material substitutes. A design which facilitates good separability of materials can also make a significant contribution.

Emission of Exhaust and Noise

Especially in our metropolitan high density areas, the increase of motor vehicle traffic has led to unforeseeable exhaust and noise pollution. Up to now, activities have mainly concentrated on reducing the injurious exhaust emissions. In view of increasing aggravation by traffic noise, these measures are not sufficient.

The guidelines take into account the requirements for reduced emission of exhaust and noise:

Polluted emissions in the exhaust should not exceed the limits proposed for 1982 by the Federal Environmental Agency.
The noise emission, measured according to ISO 362, should not exceed 73 dBA.
Even for non-limited pollutants, e.g. soot, improvements should be demonstrated.

The European cycle according to ECE R15 is the basis for exhaust limit values. Figure 4 shows the development of exhaust legislation, including the regulation which the Federal Environmental Agency proposes for 1982.

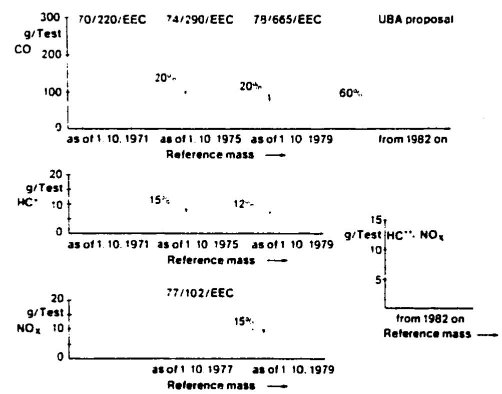

Figure 4: Development of Legislation Concerning Exhaust in Europe and in the Federal Republic

*) Measured with NDIR (C_6H_{14})
**) Measured with FID ($C_1H_{1.85}$)
—— Production test
---- Special test
Test procedure: Europa test according to ECE R15

Safety

The directives within the scope of the guidelines were formulated with preference to their effects on the accident balance:

> Active and passive safety measurement should reduce the present accident balance (fatalities, injuries, consequential costs) by at least 30 percent, in accidents involving a passenger car.

The reference quantities here are the occurrence of accidents and the market fraction of the corresponding weight category. About 85 percent of the fatalities in road traffic occur in or by a passenger car. This therefore implies that the total number will be reduced by about 25 percent.

Measurement criteria for active and passive safety measures were deliberately left unspecified. It will be the task of a committee, consisting of project observers, independent experts, and project participants, to make specifications that can be used as a basis for comparative evaluation.

Economy and Usefulness

An essential aspect in developing components and component systems for future passenger cars is the transferability of research and development results into mass-production solutions. All formulations must therefore be checked with a view to production possibilities on a large scale. In addition, demonstrable improvements must be demonstrated as regards

lifetime
ease of repair and maintenance
reliability
long-term behavior of adjustments
use of electronics.

Overall usefulness must be demonstrated in a system-analytical evaluation. As is the case for safety questions, a working committee will be used to specify the criteria.

Status of the Project

The general guidelines that have been prescribed as regards fuel consumption, exhaust and noise emissions, and vehicle safety are considered as achievable by all participants. More extensive improvements are being striven for in individual areas. The specifications manuals therefore represent developmental designs, which should yield demonstrable improvements by 30 percent, as compared to the present standard in the areas mentioned above. The automobile industry and the collegiate research community have accepted the challenge of difficult technological objectives.

The evaluation of the development concepts has been completed, and Phase 2, "Construction of Prototype Vehicles", has been started. Audi NSU, Daimler-Benz, the collegiate research community, and Volkswagenwerk are participating. Initial experimental models are supposed to be presented in March 1981.

Volkswagen Plan

Stuttgart ATZ in German Feb 80 pp 65-68

/Article by Dipl Eng Rüdiger Schmidt, Tangermünder Street 9, 3180 Wolfsburg 14/

/Text/ The worldwide shortage of petroleum makes the question of the future of the automobile a very urgent one. In a press workshop, Volkswagen has tried to delineate the resulting requirements and developmental lines. A summary of this workshop is given below.

Abstract

Good energy economy is one of the primary requirements to be met by the automobile of the future. In addition, there will be the problem of compliance with increasing demands in the area of safety, exhaust gas, and noise emissions. Competition will be tougher, and customers will expect higher performance, better quality, and less maintenance and service requirements. All of these factors will necessitate a more sophisticated automotive technology.

More complex development methods, the use of light-weight materials, and aerodynamically improved body design will lead to lower resistance vehicles. This may result in smaller engine displacement without any detrimental effects on driving performance. Fuel economy will be improved further by the increase of engine brake mean effective pressure, engine and drive train control capabilities due to more electronic systems, and fuel saving power transfer such as five-speed transmissions.

Should the energy situation become more critical in the eighties, synthetic fuels may become a feasible alternative, e.g. alcohols. Vehicle operation and occupant comfort will be improved further with the aid of electronics.

Despite the increasing technical demands the automobile will have to satisfy, the car of the future will continue to offer potentials for individual styling solutions.

1. The Automobile World of the Eighties

The auto of the eighties can be derived only from a picture of its environment. This picture will essentially be composed of the following elements:

In the developed industrial countries, the auto will remain the most important mode of passenger transportation.

The worldwide demand for passenger cars will continue to increase, however with lesser growth rates, Figure 1. This flattening is caused by increasing saturation of the volume markets in the highly developed areas like North America, Western Europe, and Japan. An equalization of the falling growth rates by the markets of the developing countries is not possible, since the broad income

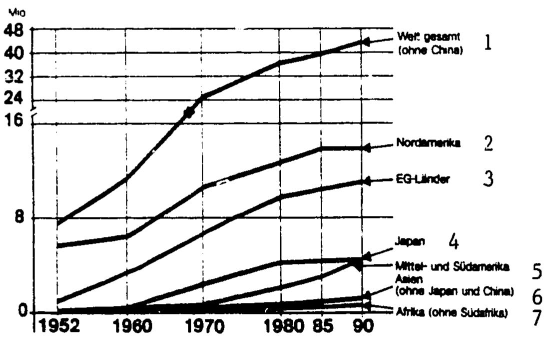

Figure 1: Worldwide Total Demand for Passenger Cars, by Regions
Key:

1. World total (without China)
2. North America
3. Common Market countries
4. Japan
5. Central and South America
6. Asia (without Japan and China)
7. Africa (without South Africa)

distribution does not exist here, which is a precondition for the beginning of mass motorization.

The falling demand growth rates will be accompanied by an increase of substitute components, Figure 2. This will make the automobile industry more dependent on business cycles.

The markets will equalize more and more. The large industrial nations (especially the USA) are beginning to recognize the significance of an international harmonization of automobile legislation to secure large, uniform markets.

Adequate production in one's own country can only be guaranteed by the use of high-grade technologies in automobile construction. Reasonable legislation in this regard will be accepted as a supporting measure.

Legislation in the safety area will quiet down. In the area of environmental protection, the reduction of noise emission as well as the discussion about diesel exhausts will occupy a central position. In addition, field monitoring of adherence to exhaust emission limits will increase. Consumer protection directives will continue to gain in significance.

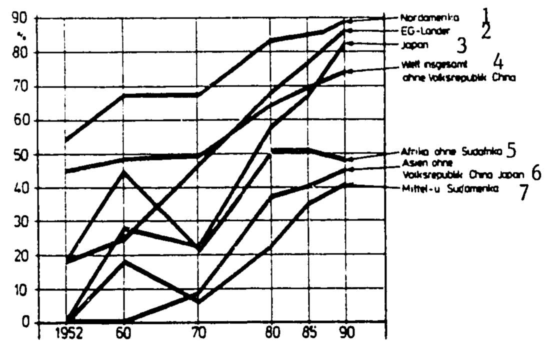

Figure 2: Worldwide Development of Spare Parts Components, i.e. Fraction of Spare Parts Demand With Respect to Total Demand

Key:
1. North America
2. Common Market countries
3. Japan
4. World total without People's Republic of China
5. Africa without South Africa
6. Asia without People's Republic of China, Japan
7. Central and South America

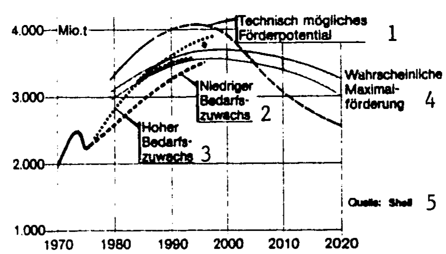

Figure 3: Prospects for Mineral Oil (World, Excluding USSR, Eastern Europe, and China)

Key:
1. Technically feasible conveyance potential
2. Low growth of demand
3. High growth of demand
4. Probable maximum conveyance
5. Source: Shell

The energy situation is of major significance for the developments of the coming decade. The installed crude oil capacities and exploitable resources are presently exceeding demand, Figure 3. At the present time, the events in Iran have caused bottlenecks in the oil supply. But apart from this, the picture will change fundamentally by the end of the eighties. Even if the exploitable raw oil reserves rise by 50 percent, the situation of oil shortage will not change significantly in the late eighties and early nineties. It is to be expected that fuel prices will therefore continue to rise strongly.

American legislation describes an average fleet consumption for any manufacturer of 8.6 1/100 km, for 1985. This is an administrative reaction to the expected fuel shortage. It has significant effects on automobile construction. In particular, it imposes, severe requirements, especially in the upper vehicle size categories, as regards construction, design, materials, and engines. This causes a "Europeanization" of the US-American automobile, and represents a threat to the European automobile industry by the US auto industry. A fleet consumption of 8.6 1/100 km (27.5 mpg) quite possibly is not yet the last step. Consumption directives of 5.9 (40) or respectively 4.7 1/100 km (50 mpg) are already under discussion in the USA.

2. Automobile Developmental Trends in the Eighties

The need for fuel savings is the decisive factor for future automobile development. For a given vehicle performance, the vehicle weight, motional resistance, power plant design, and traffic behavior are the factors which determine consumption. Safety, reduction of environmental pollution, and rising customer demands are other aspects. Electronics here will make a very significant contribution towards fulfilling these manifold requirements. The use of electronics in the automobile is constantly increasing. Finally, alternative fuels, such as e.g. methanol, will become more and more significant.

2.1 Vehicle Weight

Figure 4 shows the influence of vehicle weight on consumption, measured in the US composite cycle. In the VW Rabbit category, a reduction of vehicle weight by 100 kg implies a consumption saving of 0.2 to 0.3 1/100 km. Weight-saving possibilities result from optimal space utilization, such as e.g. by engines installed crosswise, space-saving axle designs, space-saving tank systems, omission of the spare wheel, further cooling optimization, and reducing the thickness of backrests by utilizing plastics, etc. Besides these design perspectives, the use of new materials can also reduce vehicle weight, Figure 5. By using plastics and aluminum more freely, for example, the vehicle weight of the VW Rabbit class can be reduced by 17...22 percent. However, this reduction of weight is associated with costs. The magnitude of these costs becomes clear through the example of aluminum. At the present time, an additional cost of DM 17.00 is to be expected for each percent of vehicle weight reduction.

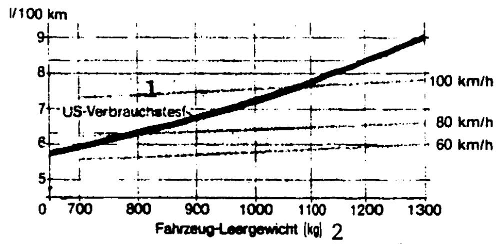

Figure 4: Effect of Vehicle Weight on Fuel Consumption
Key:
1. US consumption test
2. Vehicle empty weight (kg)

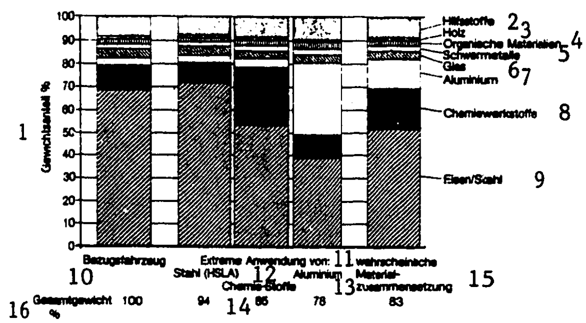

Figure 5: Weight Proportions of Materials With Alternative Designs for Weight Savings

Key:

1. Weight fraction percent
2. Auxiliary materials
3. Wood
4. Organic materials
5. Heavy metals
6. Glass
7. Aluminum
8. Chemicals
9. Iron/steel
10. Reference vehicle
11. Extreme application of
12. Steel (HSLA)
13. Aluminum
14. Chemicals
15. Probable material composition
16. Total weight

Both consider specific, presently known solutions for a two-door VW Rabbit, where 72 kg of the vehicle weight have been saved, Figure 6. The weight saving is then distributed as follows: 45 percent by using aluminum, 20 percent by using plastics, and 35 percent by design measures, including the selection of high-strength steels.

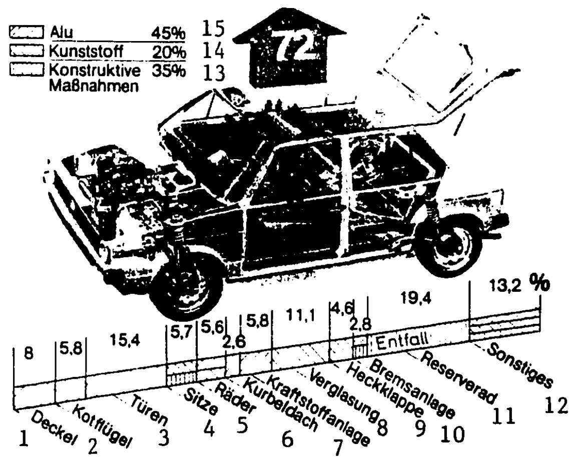

Figure 6: Weight Saving by Aluminum, Plastics, and Constructive Measures
Key:

1. Hood	9. Trunk lid
2. Fenders	10. Braking system
3. Doors	11. Spare wheel
4. Seats	12. Other
5. Wheels	13. Constructive measures
6. Sun roof	14. Plastic
7. Fuel system	15. Aluminum
8. Glass	

For example, the aluminum door yields a weight saving of 11.1 kg per vehicle, as compared to doors of steel plate. However, the material thickness here had to be increased 44 percent. This was necessary so that the same bending and buckling strength could be obtained with a lower elastic modulus. A plastic trunk lid, consisting of glass fiber-reinforced polyester resin, yields a 3 kg weight reduction as compared to the present production design. A novel damping material with 33 percent less weight could yield a further 1.6 kg weight saving with the same acoustic effectiveness.

2.2 Air Resistance

It is often assumed that air resistance is important for consumption only at high speed. Its effect on city driving is generally underestimated. However, if the air resistance in city driving is reduced by 10 percent,

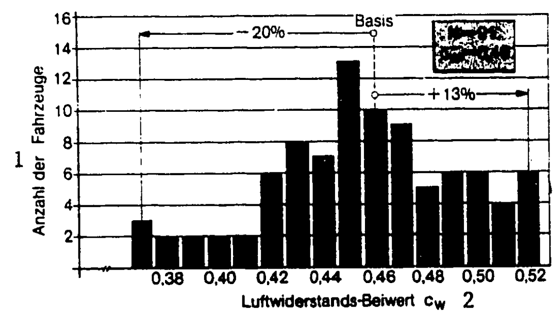

Figure 7: Air Resistance Coefficients C_W of 91 European Passenger Cars
Key:
1. Number of vehicles 2. Air resistance coefficient C_W

the reward is a fuel saving which amounts to about 3.5 percent with the Otto engine, and even 4.5 percent with the Diesel engine. The air resistance of current vehicles is shown in Figure 7. The C_W values of the vehicles selected here are representative for the European market and cover the wide range from $0.37 < C_W < 0.52$; the average value for all vehicles is here $C_W = 0.46$. Vehicles in the upper C_W range of Figure 7 here have not been developed or only very little developed in a wind tunnel. For example, to attain the range of $C_W = 0.4$, intense wind tunnel development is necessary. Volkswagen has developed a form alteration method for this purpose. Starting from a prescribed starting form, the C_W value is optimized by small changes of shape, which do not alter the overall appearance of the automobile. It has here turned out that a C_W value of 0.4 cannot be significantly improved upon by this method.

If, in the future, a significant step towards lower C_W values is to be taken, development methods would have to change. Much more intense collaboration of wind tunnel work and styling would be required even in the early stage of new model development. At Volkswagen, extensive studies have recently been performed towards drastically reducing the air resistance factor. Figure 8 shows the developmental stages for a vehicle with a relatively low air resistance. The implementability of these shapes, however, depends on the extent to which stylistics, design, and production technology can be moved to make concessions to aerodynamics, and to the extent to which the market will accept the presently still unaccustomed shapes, Figure 9.

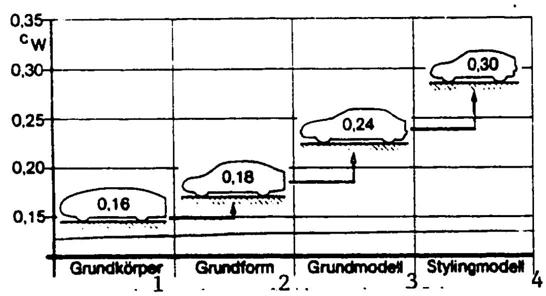

Figure 8: Development Stages for Vehicles With Low Air Resistance

Key:

1. Basic body
2. Basic shape
3. Basic model
4. Styling model

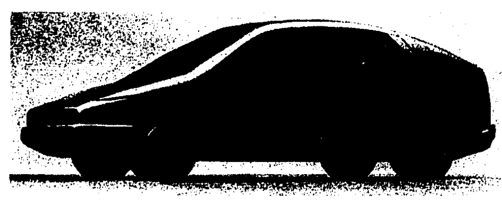

Figure 9: Model of the VW Research Passenger Car With an Air Resistance Coefficient of $C_W = 0.3$

2.3 Power Plant Designs

The power plants of the future will differ clearly from present-day engines. However, the piston engines, using the Otto and Diesel principles, will continue to play a dominating role.

Besides fulfilling the manifold legal directives for environmental protection, the point is to use the remaining free space for optimizing the engines according to consumption and convenience perspectives. Present-day driving performance should not significantly change. Two driving performance categories must here be distinguished, namely the upper performance category with a maximum speed V_{max} = 140 km/h and acceleration from 0 to 100 km/h in 20 s, and the lower performance category with V_{max} = 180 km/h and an acceleration from 0 to 100 km/h in 10 s.

If one presupposes that the vehicle weight will on the average drop by 10 percent and the air resistance by 30 percent, these vehicle improvements should be able to reduce the required engine powers by about 15 percent, while performance remains the same. With the engine itself, a continuous further development is expected in the direction towards higher average pressures and higher charging levels for the Otto and diesel engines. This is all the more necessary if fuel consumption is to be reduced since, in normal driving, the smallest possible stroke volume yields the most favorable fuel consumption. Reducing the required power and increasing the average pressure could decrease the stroke volume by up to 40 percent.

Although the Diesel engine has clear consumption advantages, it will not be able to displace the Otto engine. Introducing the exhaust turbocharger with the diesel engine will increase still further the attractiveness of this working method. Another center of developmental interest is to reduce outside noise. Reductions by 5 dB can here be achieved by encapsulating the engine, Figure 10.

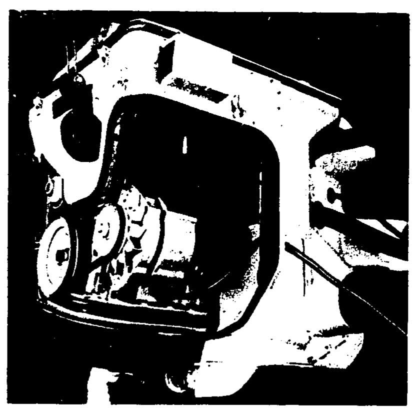

Figure 10: Thermo-Acoustic Encapsulation of an Otto Engine

2.4 Traffic Control

Volkswagen and Blaupunkt are currently developing a control and information system for the driver (LISA). It should perform the following functions:

Load the long-distance road network more uniformly.
Facilitate an optimum individual itinerary for the individual driver.
Save fuel by improving traffic conditions.
Inform the driver concerning the traffic situation and other important conditions (weather, traffic signs, etc.).

The system consists of an input and information display as well as an antenna on the vehicle and induction loops in the roadways, as well as electronic devices for operating these loops, Figure 11. It also comprises a regional central with a process computer. This computer receives all the traffic data, which are required by the road units, analyzes them, and forecasts further developments, so as to implement traffic control measures. The decisively new feature of this system is the possibility of interactive data exchange between the vehicle and the road unit. This comprises two essential functions:

specifying the destination to the system in order to make possible and optimum itinerary,

guidance and warning functions from the system to the vehicles, such as e.g. driving direction, traffic signs, warning of blockages, slippery ice, etc.

This system is being funded by the Federal Ministry for Research and Technology.

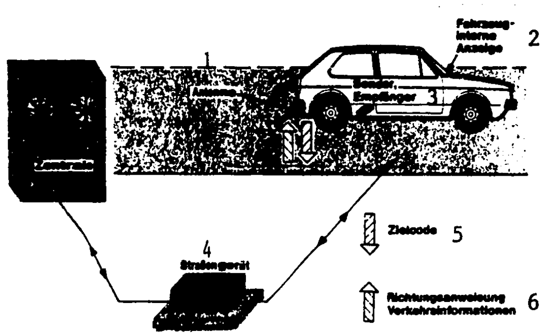

Figure 11: LISA (Control and Information System for Drivers)
Key:
1. Antenna
2. Vehicle-internal display
3. Transmitter, receiver
4. Road unit
5. Target code
6. Directional indication, traffic information

2.5 Electricity/Electronics in the Motor Vehicle of the Eighties

Electronics that is presently being developed or that may appear in the future will concentrate on three points: the driver information center, the vehicle electronics center, and the engine electronics center.

Up to now, display units have worked electrically by fine mechanics. These will be replaced by an electronic display with liquid crystals, Figure 12. Anti-blocking systems are increasingly gaining in importance. The "microprocessor" component provides new opportunities in motor control, such as e.g. ignition controlled by performance characteristics, recycling of the exhaust, etc. In this way, engine behavior can further be optimized with respect to consumption, exhaust, and drivability.

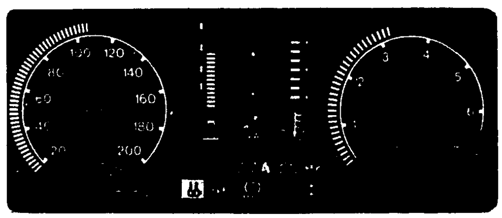

Figure 12: Electronic Display for the Instrument Board

Electronic devices presently under development will make up about 4 percent of the net production costs of a vehicle, in 1983. Beyond this time, another increase of 4 percent is forecast for the following years. In the late eighties, it is expected that electric/electronic devices will make up about 15 percent of the production costs of an average automobile.

2.6 Alternative Fuels

As it has done in the past, VW continues to work on the utilization of new fuels, such as e.g. alcohols. As is well known, these researches have shown that the use of methanol or ethanol in automobiles presents no basic difficulties. Studies concerned with the production of these fuels, from primary fossil energy media or from biomass, therefore presently stand in the forefront. The feasibility of producing methanol from coal, natural gas, or city wastes have already been the subject of many reports. However, relatively little is known concerning the significance of alcohol fuel technology, using plants as basic material, for the energy economy and particularly for the automobile industry in the future.

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A question of primary significance here is whether biotechnology does not require a greater energy input than can be extracted again in the form of alcohol and possible byproducts. Initial energy balances have shown that the energy input for sowing, reaping, and processing sugar cane is 36 percent smaller and for sugar millet is about 7 percent less than the energy gain, that is the amount of alcohol (1900 liters) which is annually required to operate an ethanol-driven vehicle. In other words, biomass is an overall generator of energy. However, with manioc, the energy balance is negative. Here, sowing, reaping, fertilizer, and processing require more energy than is obtained, in fact about 39 percent more.

Electrical propulsion systems also belong among propulsion systems with alternative fuels, since electricity can be obtained from many energy media. However, our opinion is that only a very small percentage of vehicles in the late eighties will have an electrical drive. They key to a successful E-mobile lies in battery improvements. In any case, an alkaline battery of the nickel-iron type is technically feasible. Prototypes already exist. The range of an electric Rabbit would be 210 km maximum at constant speed or respectively 105 km in city traffic, Figure 13. A sodium-sulfur battery of the same weight would even achieve 350 km or respectively 175 km.

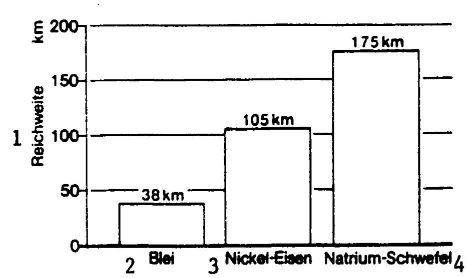

Figure 13: Passenger Car Ranges in City Traffic With Various Energy Storage Media

Key:

1. Range	3. Nickel-iron
2. Lead	4. Sodium-sulfur

2.7 Styling

Finally, one must raise the question whether automobiles of the future will not resemble each other more and more, because of the many technical requirements and increasing functionality. Beyond that, the new requirements, especially those based on low C_W values, will pose new and difficult problems as to styling. However, as has happened in the past, so also in the future, a large number of individual and typical solutions will be found. In the future, these will lead to a broad spectrum of external appearance.

Daimler-Benz Plan

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/Article by Dr. Eng. Bernd Strackerjan, Erikastrasse 32, 7000 Stuttgard 60/

/Text/ Daimler-Benz AG is participating in the project "Demonstration of Automobile Engineering Research Results in Integrated Overall Designs of Passenger Car Experimental Models", by developing a limousine, which falls into the upper weight category proposed by the Research Ministry. In the following paper, the foreseeable boundary conditions of automobile construction point to conclusions about the design of future passenger cars of this type. The planned vehicle, together with its principal systems, is described.

Basic Conditions for Future Automobile Construction and Their Implications on the Mercedes-Benz Research Vehicle "Car 2000"

Abstract

Population statistics (Figure 1) and forecasts of the amount of time available for travelling (Figure 2) suggest that the future will see a further growth of private transport and a large demand for automobiles suitable for long journeys (Figure 3). As such automobiles should have adequate luggage space, amply proportioned passenger compartments, sufficient power, and should also be comfortable, Daimler-Benz decided to design their research car within the upper weight range of the BMFT specifications.

It is proposed that besides gasoline and Diesel engines a dual-shaft gas turbine with ceramic components will be used as a propulsion unit for this car (Figure 6). The advantages are low weight, good vibration characteristics, multi-fuel capability, easy maintenance and a low emission level. Fuel consumption is higher than for piston engines at low speeds, but is considerably lower at high speeds (Figure 9). The driver can select different driving programs so as to reduce fuel consumption during overland trips or reduce consumption and external noise in urban areas (Figure 11).

Safety is to be improved by the utilization of advanced brake and acceleration controls, a lead steering, and a new tire system.

Body improvements are primarily intended to reduce drag and increase passenger and pedestrian safety. Driver perception is to be improved by means of an anti-collision radar.

Maintenance economy will be increased by means of a system of maintenance adapted to actual requirements. In addition to a diagnostic computer, an electronic trip computer will supply the driver with all the relevant data on the status of the various systems.

A route computer, a destination guidance system and radio-telephone will facilitate fast and comfortable long-distance travelling.

The design proposed satisfies the desire of motorists for sufficient size, power, comfort and safety and the demands by society that the incidence of accidents, consumption of energy and emission of pollutants will be reduced and that motor vehicles have a multi-fuel capability.

1. Introduction

The project "Demonstration of Automobile Engineering Research Results in Integrated Overall Designs of Passenger Car Experimental Models" of the Federal Research Ministry affords Daimler-Benz AG the opportunity of testing out in a demonstration vehicle the practical suitability of novel technologies and components, which it currently has under development. In Phase 1 of the project, the expected development of automobile engineering boundary conditions were worked out in the areas of traffic, energy, and accidents. From this, the design of the research passenger car was derived. The conclusions therefrom are reported below.

2. Population and Mobility

Population forecasts predict that the residential population of West Germany will continually decline in the coming years. However, this does not entail a reduction of total mobility and the resulting traffic output. The presumed age structure of the population indicates that especially mobile age groups, such as wage earners between 16 and 65, or groups with a great deal of leisure time, such as the independently wealthy, will not decline. For the large group of the independently wealthy, it will be true that they will to a much greater extent have driving licenses and will do a great deal more driving, Figure 1.

It may be assumed that, by the end of the century,

the weekly working time will decrease,
the annual vacation time will increase, and
the retirement age will drop,

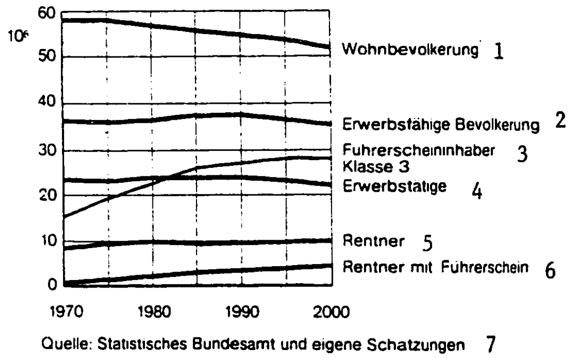


Figure 1: Population Forecasts for the Federal Republic of Germany

Key:

1. Residential population
2. Employable population
3. Owners of driving licenses Class 3
4. Actively employed persons
5. Independently wealthy
6. Independently wealthy with driving license
7. Source: Federal Office of Statistics and Own Estimates

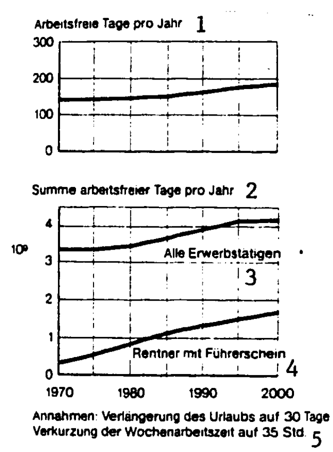


Figure 2: Available Leisure Time of Gainfully Employed Persons as Well as of the Independently Wealthy with Driving Licenses

Key:

1. Leisure days per year
2. Sum of leisure days per year
3. All gainfully employed persons
4. Independently wealthy with driving license
5. Assumptions: Extension of vacation to 30 days, shortening of working week to 35 hours

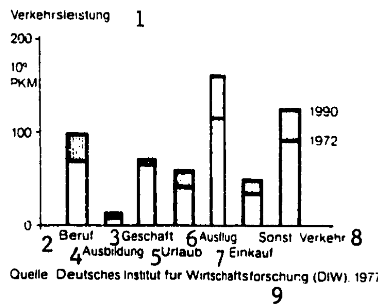


Figure 3: Growth of Individual Traffic 1972 to 1990, in Passenger-Kilometers PKM

Key:

1. Traffic output	6. Excursions
2. Occupation	7. Shopping
3. Business	8. Other traffic
4. Education	9. Source: German Institute for Economic Research (DIW) 1977
5. Vacation	

All these factors result in a considerable increase of leisure time, Figure 2. This time can be used for travel. Economic research institutes therefore also expect the greatest absolute growth of individual traffic output in excursion traffic, and the greatest relative increase in vacation traffic. Business traffic is already at a very high level and will again rise slightly, Figure 3. The demand for passenger cars, both for business and private travel, will therefore increase in the future.

3. Vehicle Design

Within the scope of the above-mentioned project, Daimler-Benz AG has developed a passenger car in the upper weight category. Its application spectrum in business, excursion, and vacation traffic, with its high average occupancy between 1,4 and 2,6, and its large annual and daily driving range, demands the following conditions:

interior space for five persons,
high driving, air conditioning, and noise comfort,
large baggage space with comfortable loading and unloading,
high trailer load for business and leisure time needs,
adequate motorization for longer journeys,

4. Social Interests

The requirements imposed by the vehicle design must be harmonized with social interests in conserving energy and resources, safety requirements, environmental compatibility, economy, and usefulness.

4.1 Preservation of Energy and Resources

All energy forecasts known at this time indicate that the production of petroleum will traverse its maximum even before expiration of the present century. Currently known alternative propulsion technologies in road traffic either have significantly poorer utilization of primary energy or demand much heavier or larger storage media for a given driving distance. For this reason, alternative energies will be a recourse only where the application spectrum so permits, or where strict environmental requirements, for example freedom from exhaust at the use site, so require.

Liquid hydrocarbons will represent the main energy sources for road traffic up into the next century. However, scarcity and high price are to be expected. This urgently presses the requirement for saving driving energy.

A reduction of fuel consumption demands an optimization of vehicle subassemblies, taking into account the type of application. Statistical considerations - shown in Figure 4, by way of example, in terms of the Mercedes-Benz passenger car fleet - indicate that vehicles of the upper category will move on intown roads only for one-fourth of their driving range. Their highway fraction will be 35 percent. The distribution function of travelling speed during unhindered driving, Figure 5, shows that 75 percent of the passenger cars run slower than 85 km/h on federal or provincial roads. On highways, 75 percent of the drivers do not exceed 128 km/h. The same studies show that limousines on the average run at the same speed that is specified by the 75 percent value. Their consumption therefore must be optimized not according to the BMFT proposal or according to a three-part weighting appropriate for an average passenger car, but in a cycle with 25 percent EFZ (European driving cycle in the city), 40 percent constant at 85 km/h, and 35 percent at 128 km/h.

4.1.1 Propulsions Units. The basis for low fuel consumption is a propulsion unit that is matched to the overall driving cycle.

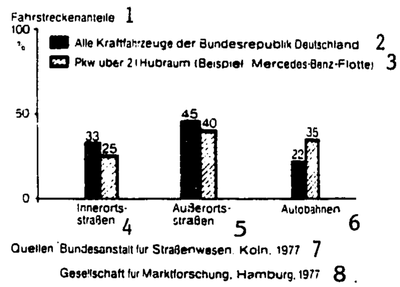


Figure 4: Distribution of Driving Distances Among Road Categories
Key:
1. Driving distance fraction
2. All motor vehicles in the Federal Rpublic of Germany
3. Passenger cars above 2 1 displacement (example; Mercedes-Benz fleet)
4. Inner city streets
5. Out-of-town streets
6. Highways
7. Source: Federal Institute for Road Traffic, Cologne 1977
8. Society for Market Research, Hamburg 1977

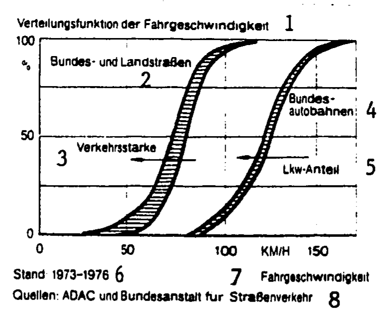


Figure 5: Distribution Function of Travel Speeds of Passenger Cars During Unhindered Driving
Key:
1. Distribution function of passenger speeds
2. Federal and Provincial roads
3. Traffic intensity
4. Federal highways
5. Truck fraction
6. Status: 1973-1976
7. Driving speed
8. Sources: ADAC and Federal Institute for Road Traffic

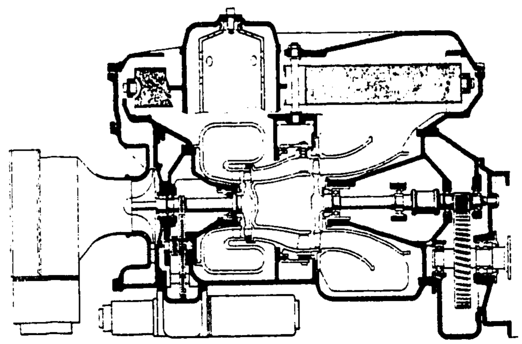


Figure 6: Schematic Representation of the Mercedes-Benz Research Gas Turbine

Gas Turbine

For the vehicle that is being planned here, with a large proportion of long-distance driving, Daimler-Benz AG considers a gas turbine a suitable propulsion alternative. The double-shaft gas turbine that is currently being developed by the company, Figure 6, has a rotating regenerator as a heat exchanger, a single-stage radial compressor, and a single-stage axial real turbine with adjustable guide baffles.

All components in the area of the turbine rotor, that are subject to hot gases, Figure 7, as well as the ignition chamber and the heat exchanger disk should be made of ceramic. In this way, it will be possible to increase the compressor turbine entry temperature, as compared to metal turbines, by 300°C to a temperature of 1623°K. Figure 8 shows the expected improvements in consumption. The propulsion system is electronically controlled through the fuel quantity and guide baffle position of the active power turbine.

Figure 7: Ceramic Rotor of the Mercedes-Benz Research Gas Turbine

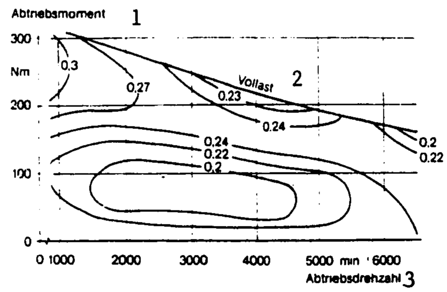


Figure 8: Mercedes-Benz Research Gas Turbine: Relative Reduction of Consumption by Increasing the Termperature from 1323°K to 1623°K, between 20 and 30 percent

Key:

1. Driving moment 2. Full load 3. Driving rpm

Table 1 shows the performance data, the unit weight, and the consumption characteristics in connection with the Mercedes-Benz research passenger car. These values will be achievable in the first development stage, in which the full final temperature is not yet realized. The further development of the gas turbine promises a reduction of fuel consumption. Among other things, it is here planned to raise the temperature to the full final value, and also to use improved turbo machinery. In this way, the data of Development Stage II in Table 1 will be attained.

Piston Engines

As an Otto engine, 3.2 l V8 engine with comparable rated power and with fuel injection is proposed. It can be stepped down to 6- and 4-cylinder operation by shutting off cylinders. If necessary, the exhaust gas is treated by an O_2-probe in a three-way catalyst (TWC). This engine is primarily designed for economy, while giving up peak performance.

A comparable diesel engine of the V8-type, with a low-soot secondary chamber and exhaust filter, has about 4.4 l displacement. It can be equipped with a fast starting device.

The most important data of these engine variants are listed in Table 2.

Table 1: Technical Data of the Mercedes-Benz Research Gas Turbine in Two Development Stages

	Development Stage	I	II
Rated Power P_{nom}	kW	94	110
Rated rpm n_{nom}	1/min	6500	5000
Maximum torque M_{max}	Nm	332	550
with rpm n_{Mmas}	1/min	0	0
Total weight of the propulsion system G_{tot}	kg	240	240
Starting time t_{start}	s	6	6
Degree of nonuniformity	-	0	0
Mass equalization, free forces	-	0	0
free moments	-	0	0
Multi-material capability	-	yes	yes
Fuel		diesel fuel	
Fuel consumption in the EFZ	1/100 km	19,4	14.2
at 85 km/h	1/100 km	7,1	5.4
at 90 km/h	1/100 km	7,2	5.5
at 120 km/h	1/100 km	8,0	6.7
at 128 km/h	1/100 km	8,4	7,5
Mixed cycle	1/100 km		
50% EFZ, 25% 90 km/h, 25% 120 km/h		13,5	10,1
25% EFX, 40% 85 km/h, 35% 128 km/h		10.6	8,3
Lubricant consumption	1/1000 km	0,1	0.03
Pollutants in the EFZ CO	g/Test	5.4	3.7
NO_X	g/Test	1.1	0.8
Solids	g/Test	at the test limit	

Comparison of Propulsion Systems

Compared with piston engines, the advantages of the gas turbine are its great elasticity, its low weight, and its excellent vibrational behavior, Its multi-material capability is nearly unlimited, Another advantage will be ease of maintenance, since it works without cooling water circulation and since its parts, except for the bearings, are not subject to wear,

The advantages of internal combustion engines are in their fast reaction to load changes as well as in their shorter starting times,

Table 2; Technical Data of More Advanced Piston Engines

		Otto Engine	Diesel Engine
Construction type		V8	V8
Operating mode with cylinders that can be switched off		V8,V6,V4	V8
Displacement	1	3.2	4.4
Rated power P_{nom}	kW	110	110
Rated rpm n_{nom}	1/min	4500	4600
Maximum torque M_{max}	Nm	245	263
at rpm	1/min	3100	2400
Total weight of the propulsion system G_{tot}	kg	270	300
Starting time	s	<1	5
Degree of nonuniformity	-	0.02	0.0666
Mass equalization, free forces	-	4th order	
free moments	-	4th order	
Multi-material capability	-	not anticipated	
Usual type of fuel		gasoline (lead free)	diesel fuel
Fuel consumption in the EFZ	1/100 km	10.8	12.7
at 85 km/h	1/100 km	7.5	7.0
at 90 km/h	1/100 km	7.9	7.3
at 120 km/h	1/100 km	9.7	9.1
at 128 km/h	1/100 km	10.9	9.8
Mixed cycle:			
50% EFZ, 25% 90 km/h, 25% 120 km/h		9.8	10.4
25% EFX, 40% 85 km/h, 35% 128 km/h		9.5	9.4
Lubricant consumption	1/1000 km	0.3	0.3-0.4
Pollutants in the EFZ CO	g/Test	10*	5
NO_x	g/Test	2	3
		5.5*	10
C_nH_m	g/Test	3	7

* With O_2 probe and three-way catalyst

The lubricant consumption of gas turbines is low, and oil changes are not expected.

The fuel consumption of gas turbines, at low speeds and at fluctuating operation, is higher than that of piston engines, but is considerably lower at high and constant driving speeds, Figure 9.

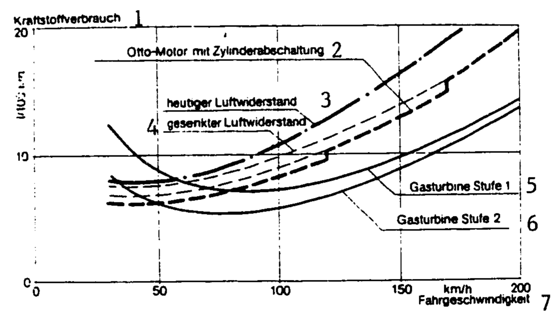


Figure 9: Fuel Consumption of the Gas Turbine in Comparison to the V8 Otto Engine With Cylinder Shut-off

Key:

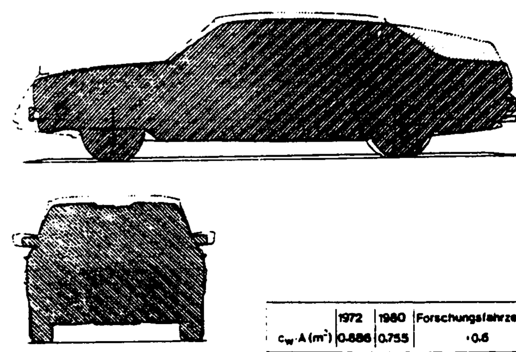
1. Fuel consumption
2. Otto engine with cylinder shut-off
3. Present air resistance
4. Lowered air resistance
5. Gas turbine Stage 1
6. Gas turbine Stage 2
7. Driving speed

Only in its second development stage, will the gas turbine be able to surpass the limit values of the mixed consumption proposed by the BMFT, with 50 percent EFZ, and 25 percent each at 90 km/h and 120 km/h, Table 1. For this special application, the proposed division (25 percent EFZ, 40 percent 85 km/h, 35 percent 128 km/h) should be used as a basis. In that case, fuel consumption will already in the first phase be comparable to that of piston engines, and will afford a considerable improvement in the second development stage.

Gears

All propulsion systems are combined with an electronic-hydraulic automatic transmission, which allows a variable choice of program (see Section 4.1.5).

4.1.2 Air Resistance. With the large passenger car that is designed here, and which has a high proportion of long-distance driving, air resistance has a great effect on fuel consumption, Figure 9. With adequate interior space and normal entering conditions, the frontal surface A cannot be significantly lowered. The aerodynamic shaping of the car body is therefore highly significant. Figure 10 gives an impression about the means that are to be applied to reduce the product



	1972	1980	Forschungsfahrzeug 1
$c_w \cdot A$ (m^2)	0.886	0.755	·0.6

Figure 10: Mercedes-Benz Research Passenger Car: Aerodynamic Comparison With Previous and Present Designs

Key:
1. Research vehicle

$c_w \cdot A$ to 0.6 m^2 for the Mercedes-Benz research passenger car: optimization of the bow area with cooling air guidance, smooth side surfaces, underbody coating, comb stern.

4.1.3 Secondary Units. In order to attain low driving consumption, an attempt will be made to reduce the performance requirements of all secondary units. In particular, a study is being made concerning which auxiliary units can be supplied from common energy sources.

4.1.4 Efficiencies. The reduction of transfer losses in the power train further contributes to reducing consumption. One should try to improve the efficiency of automatic transmissions, force transmission, and the rear axle. This also includes the utilization of tires with reduced rolling resistance.

4.1.5 Driving Programs. A significant reduction of consumption can be obtained with a steady mode of driving. This is achieved by three programs that can be selected by the driver, for "city driving", "economy long-distance driving", and "fast long-distance driving". These programs affect both the power delivered and the maximum rpm of the propulsion system, and the cycling of the automatic transmission, Figures 11 and 12. A kickdown circuit permits attaining full acceleration in emergencies, from every economic driving program.

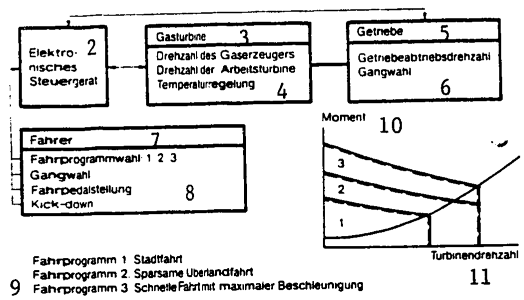


Figure 11: Driving Program for Gas Turbine Propulsion

Key:

2. Electronic control unit
3. Gas turbine
4. rpm of the gas generator,
   rpm of the working turbine,
   temperature control
5. Transmission
6. Transmission driving rpm
   Cycle selection
7. Driver
8. Driver programming selection: 1 2 3
   Cycle selection
   Driving pedal position
   Kickdown
9. Driver program 1: city driving
   Driver program 2: economic long-distance driving
   Driver program 3: fast driving with maximum acceleration
10. Moment
11. Turbine rpm

4.1.6 Weight Savings. An attempt will be made to lower the vehicle weight by using materials with the lowest possible energy content. For this reason, the piston engines will be equipped with an engine block and with cylinder heads of light metal castings. Various built-on components of the car body will be fabricated of fiber-reinforced plastics. The use o' high strength sheet metal with reduced wall thickness should yield a further weight saving.

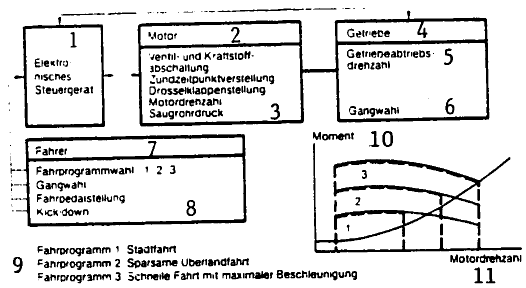


Figure 12: Driver Program for Engine Drive with Cylinder Shutdown

Key:

1. Electronic control unit
2. Engine
3. Valve and fuel shutdown
   Change of ignition timing
   Choke position
   Engine rpm
   Suction tube pressure
4. Transmission
5. Transmission driving rpm
6. Cycle selection
7. Driver
8. Driver programming selection: 1 2 3
   Cycle selection
   Driving pedal position
   Kickdown
9. Driver program 1: city driving
   Driver program 2: economic long-distance driving
   Driver program 3: fast driving with maximum acceleration
10. Moment
11. Engine rpm

4.2 Environmental Compatibility

The forecasts of the mineral oil industry and of the economic research institutes predict a passenger and station wagon stock of 23 to 25,9 million units for the Federal Republic of German, by the year 1990. At the same time, there will be about 1,7 million trucks of all types in the Federal Republic. This inventory increase by about one quarter will entail increased environmental pollution.

4.2.1 Exhaust Emissions. As the traffic density increases and as speeds decrease, exhaust emission in metropolitan main traffic networks will continue to rise. To reduce exhaust pollution, both constructive and traffic control measures, as well as clean engine exhaust gases will be necessary.

The planned propulsion systems for the research passenger car are supposed to stay below the emission tolerances
CO: 42 g/Test HC + NO_X: 10 g/Test
in the reference weight category 1700 to 1930 kg. These emission tolerances were originally planned by the Federal Environmental Agency for 1982, and are set down in a specifications manual. With the Otto engine, this presupposes expensive after-treatment measures of the exhaust and lead-free gasoline. The pollutant component in the exhaust of the gas turbine will, already in the first development stage, be better than that of modern Diesel engines, compare Tables 1 and 2.

4.2.2 Noise Emission. To reduce noise pollution, improvements are necessary both in road construction and in traffic control, as well as on the vehicle itself. The required 73 dB(A) according to the ISO measuring method 362 are to be achieved by the following measures:

adequate damping of the intake and exhaust noises,
complete covering of the engine space on the bottom,
choking of motor power and speed in the city driving program,
reduction of rolling noises by specific profile design of the tires.

4.3 Safety

Despite the constant growth of the motor vehicle stock, the number of traffic accidents in the Federal Republic of Germany has remained nearly constant in the previous 10 years. As a consequence of improved vehicle technology, increased road construction, and longer driving experience, the accident rates in Germany, as in all the highly motorized countries, have a clear trend toward falling accident rates per driven mile. The endeavor to decrease the absolute number and consequences of traffic accidents, the motor vehicle industry has been called upon further to increase the active and passive safety of its products.

The reference points for improving active safety cannot be obtained from public accident statistics. Vehicles have made progress in the following areas:

driving safety,
conditioning safety, and
perception safety.

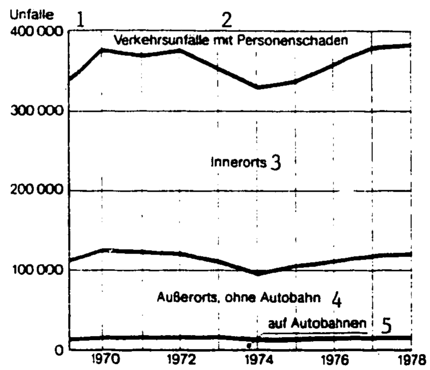


Figure 13: Traffic Accidents with Personal Injury in the Federal Republic of Germany

Key:

1. Accidents
2. Traffic accidents with personal injury
3. Intown
4. Out of town, excluding highways
5. On highways

This progress can already be measured from the falling accident rate.

Evaluation of accident statistics can indicate the areas in which passive safety progress is possible:

Nearly 70 percent of all traffic accidents with personal injury, in Germany, result in town. About 27 percent of these accidents happen out of town, and about 4 percent on federal highways. Although the absolute number of accidents has fluctuated in previous years, Figure 13, their percentage distribution among accident sites has remained nearly constant. Assuming that this percentage composition will also remain approximately constant in the future, attempts should be made to reduce the consequences of accidents primarily in city accidents, secondly in out-of-town accidents, and only finally in highway accidents. With intown accidents, crossing collisions dominate, as well as collisions with pedestrians. Despite the generally lower driving speeds and the higher protective action of their vehicles, about half the injuries and a quarter of the fatalities in intown accidents are occupants of passenger cars, Figure 14. Nearly 20 percent of traffic participants injured intown, and more than 40 percent of the fatalities, are pedestrians.

Driving off the roadway is the main cause for out-of-town accidents (except highways). This is followed by crossing accidents and frontal collisions. The driving speeds are relatively high here, and the risk of

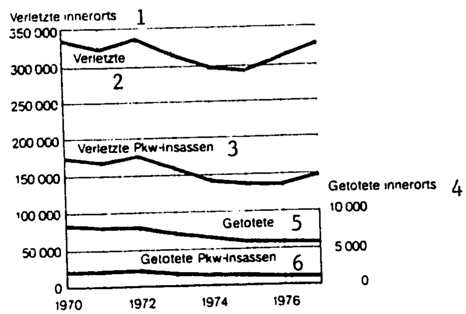


Figure 14: Intown Accidents in the Federal Republic of Germany

Key:
1. Injured, intown
2. Injured
3. Injured passenger car occupants
4. Intown fatalities
5. Fatalities
6. Passenger car occupant fatalities

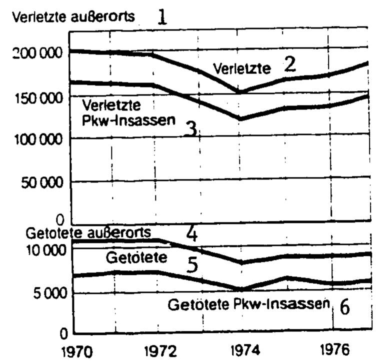


Figure 15: Out-of-Town Accidents in the Federal Republic of Germany

Key:
1. Out-of-town injuries
2. Injuries
3. Injured passenger car occupants
4. Out-of-town fatalities
5. Fatalities
6. Passenger car occupants fatally injured

the occupants is correspondingly greater, with 80 percent of injuries and 65 percent fatalities, Figure 15.

Accidents on federal highways primarily result by running off the roadway. Collision with a passing vehicle is almost as frequent. A reduction of the accident ballance will be striven for with the following measures:

Driving Safety:

To maintain the steerability and trueness to course, even at high delays and driving forces, a braking and accelerating control should be installed and tested.

An automatic steering mechanism with an assist proportional to the steering rate can reduce the steering effort especially during fast steering maneuvers.

In connection with the Continental Rubber Works AG, improvements should be attained in driving stability and friction-type contact by a new system of tires.

The air pressure in the tires should be monitored.

Conditioning Safety:

An automatic transmission is necessary to unbruden the driver.

A more highly developed interior air conditioning system is very significant especially with vehicles designed for long-distance travelling.

Perception Safety:

Radar distance measurements will give a warning if the distance falls below the safety margin, in the more frequent traffic lines expected in the future.

Passive Safety:

To reduce the consequences of an accident, and as a supplement to a comfortable, seatbelt system, a passive air bag system should be tested.

The effects of frequent veer-off and crossing accidents should be attenuated by improved flank protection.

The consequences of pedestrian collisions could be attenuated by a new hood contour, an elastic front, and a cushioned A-column.

To reduce stress on the occupants, with frequent and severely injurious frontal collisions, a nonsymmetrical front end structure should be tested.

4.4 Economy and Usefulness

As wages continue to rise, reduction of repair expenditures will in the future become even more significant. For this reason, rare visits to the shop and the smallest possible number of maintenance items will be desirable.

Oil changes and adjustment work on the propulsion system today specify the length of maintenance intervals. Monitoring work and preventive replacement of consumable parts is undertaken at the same time. Under usual stresses, these would not survive a longer maintenance interval.

Maintenance work on the gas turbine will be limited to replacing air and oil filters. An oil change is not necessary. The function of the filters and the height of the oil level is measurable. Consequently, a need-dependent monitoring system can be implemented. If these are components are adequately dimensioned, this will allow very long driving distances between maintenance work.

It is presupposed that the remaining parts that are subject to wear will be adapted to the very long working times, and that components that are safety-critical will be monitored, and that their failure will be indicated to the driver. An onboard monitoring computer will take over these tasks. For the driver's information, a travel computer should be installed, which transmits to the driver important data concerning the vehicle condition, such as fluid levels, fuel consumption, etc., at those times when the driver requires them.

A routing computer should serve to find the shortest connection between the origin and destination. The long-distance road network and the locations that can be reached thereby should be stored in this computer. After the destination is inputted, the routing computer will indicate all intermediate stations, highway exits, and the respective distance to the destination as well as the probable arrival time. A destination guidance system can be superposed on this routing computer. Depending on traffic conditions, this system will indicate favorable deviations from the planned route.

Finally, the vehicle occupants should be able to make connection with telephone subscribers, to make emergency calls, and to receive traffic information. For this purpose, we propose a driver communications system, which consists of mobile and fixed transmission and receiving units, which are connected together through the automobile antenna and through a cable laid out along the long-distance road network. Thirty channels of this system should be reserved for interactive communication, and one channel each for emergency calls and traffic information.

5. Summary

Within the framework of the research project, Daimler-Benz AG will present a vehicle of the upper weight category, Figure 16. In this vehicle, the applicability of novel subassemblies and technologies will be tested. The most important of these have been described in the present paper. Although the choice of propulsion unit is very important in this project, because of its effect on fuel consumption, exhaust emission, and maintenance requirements, the remaining interests of users and of society in general, safety, environmental compatability, and economy, are not neglected.

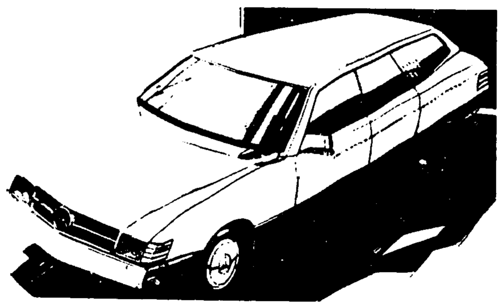


Figure 16: Mercedes-Benz Research Passenger Car

In contrast to similar research projects in the past, where safety, for example, occupied the forefront, this vehicle will attempt to fulfill all requirements without one-sided priorities.

The author thanks his colleagues, who supported him in writing this paper.

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END